Project Managemant Plan & Project Specific Clarifications

(continued)

Group Wave 17

We have included the following project specific Scope of Work and Assumptions for the projects in Group Wave 17.

Group Wave #	Proj Title #	Circuit Name	PGE Job Order #	Circuit #	Mileage	# Spans	Discrepancies	Steel Locations	Tentative IFC Date	Shared Circuit Name
17	W17-1	Mesa-Sisquoc 115kV	30945437	10173	17.6	288	8	1	5/1/2014	Callendar SW Sta-Mesa 115kV, Santa Maria-Sisquoc 115kV
	W17-2	Moss Landing-Green Valley #1 & #2 115kV	30956768	10213/	14.3/	80/84	7	5	6/1/2014	N/A
	W17-3	Moss Landing-Salinas #1 & #2 115kV	30993367	10216/ 10217	12.0/ 12.1	66/70	2	1	6/1/2014	N/A
	W17-4	Moss Landing-Salinas-Soledad #1 & #2 115kV	30932663	10218/ 10219	53.7/ 53.6	266/ 264	55	29	6/22/2014	N/A
				Wave 17 Totals	*17.6*	*288*	*72*	*36*		

The following tower types and top cage extensions have been modeled for previous projects and will be used for the projects included in Group Wave 17: 2B, 2A, AH, and BHH.

The following tower types and top cage extensions will need to be modeled to be used for the projects included in Group Wave 17: 2C-D.E., 2D-D.E., AL, and AL (SHORT). Four unknown tower types will also need to be modeled and will potentially require new extension designs. One basic tower of each type will be modeled as well as one extension for each tower type will be modeled/designed.

Burns & McDonnell has performed preliminary over-tension analyses for the circuits in this RFP. This preliminary analysis has only identified the sections of the affected circuits. A final detailed over-tension analysis will be completed as part of our engineering services and is included in our pricing, the results of which will be reported and presented to PG&E, in the format of PG&E's choosing, for further consideration. The results of our preliminary analyses are listed by circuit below.

Mesa-Sisquoc 115kV

- Raise one (1) unknown tower type at Structure 000/005 or re-tension span 000/005 to 000/006.
- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moss Landing-Green Valley #1and #2 115kV

- Raise two (2) 2A towers, two (2) 2B towers and one (1) 2C-D.E. tower at Structures 000/003, 001/011, 009/052, 012/070, and 013/075.
- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moss Landing-Salinas #1 and #2 115kV

- Raise one (1) AH tower at Structure 011/060.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 007/043 – 011/062. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moss Landing-Salinas-Soledad #1 and #2 115kV

- Raise sixteen (16) AH towers, two (2) 2D-D.E. towers, four (4) AL towers, one (1) AL (SHORT) tower, two (2) 2BHH towers, and four (4) unknown towers.
- A portion of this circuit was not included in the assessment because it was under construction at the time of survey. It is assumed that no spans in this section will require mitigation.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 037/235 – 045/287A and 029/186 – 030/196. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Group Wave 18

We have included the following project specific Scope of Work and Assumptions for the projects in Group Wave 18.

Group Wave #	Proj Title #	Circuit Name	PGE Job Order #	Circuit #	Mileage	# Spans	Discrepancies	Steel Locations	Tentative IFC Date	Shared Circuit Name
18	W18-1	Kings River-Sanger-Reedley 115kV	30932651	10129	43.4	372	63	26	6/10/2014	Balch-Sanger 115kV
	W18-2	Oakhurst Tap 115kV	30932667	100338	18.4	208	5	0	-	N/A
				Wave 18 Totals	*61.8*	*580*	*68*	*26*		

The following PG&E tower types and top/waist cage extensions have been modeled for previous projects and will be used for the projects included in Group Wave 18: A.

The following tower types and top cage extensions will need to be modeled to be used for the projects included in Group Wave 17: C-D.E. One unknown tower type will also need to be modeled and will potentially require a new extension design. One basic tower of each type will be modeled as well as one extension for each tower type will be modeled/designed.

Burns & McDonnell has performed preliminary over-tension analyses for the circuits in this RFP. This preliminary analysis has only identified the sections of the affected circuits. A final detailed over-tension analysis will be completed as part of our engineering services and is included in our pricing, the results of which will be reported and presented to PG&E, in the format of PG&E's choosing, for further consideration. The results of our preliminary analyses are listed by circuit below.

Kings River-Sanger-Reedley 115kV

- Raise three (3) 2C-D.E. towers, twenty-two (22) A towers, and one (1) unknown tower at Structures 17/90, 23/122, 23/124, 25/130, 25/132, 26/134, 26/138, 26/139, 27/141, 28/147, 28/148, 28/150, 29/152, 29/154, 29/156, 30/158, 30/160, 31/166, 32/170, 32/171, 32/174, 33/176, 33/178, 33/180, 34/182, and 21/114D.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 16/89 – 18/96. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Oakhurst Tap 115kV

- Replace five (5) steel poles at Structures 000/006, 007/001, 007/003, 011/000, and 013/001.
- **Based on the answer to question 2.6 found in Addenda 3 and our prior experience with NERC mitigation projects, it is assumed that these light duty steel poles will be designed by PG&E's RMC. No scope of work for this project is included in this proposal.**

Group Wave 19

We have included the following project specific Scope of Work and Assumptions for the projects in Group Wave 19.

Group Wave #	Proj Title #	Circuit Name	PGE Job Order #	Circuit #	Mileage	# Spans	Discrepancies	Steel Locations	Tentative IFC Date	Shared Circuit Name
19	W19-1	Moraga-Lakewood 115kV	30950803	10420	8.0	68	15	11	7/19/2014	Sobrante-Moraga 115kV
	W19-2	Moraga-Oakland "J" 115kV	30932659	10204	17.7	149	5	3	7/19/2014	San Leandro-Oakland J 115kV, Moraga-San Leandro #3 115kV
	W19-3	Moraga-San Leandro #1 115kV	30932660	10205	11.2	84	5	4	7/19/2014	Moraga-San Leandro #2 115kV
	W19-4	Moraga-San Leandro #2 115kV	30932660	10206	11.0	81	6	2	7/19/2014	Moraga-San Leandro #1 115kV
	W19-5	Moraga-San Leandro #3 115kV	30932661	10207	11.0	79	2	1	7/19/2014	Moraga-Oakland J 115kV
				Wave 19 Totals	*58.9*	*461*	*33*	*21*		

The following PG&E tower types and top/waist cage extensions have been modeled for previous projects and will be used for the projects included in Group Wave 19: SIERRA-STD, 2A, 2BO, AH, and BH.

The following PG&E tower types and top/waist cage extensions will need to be modeled to be used for the projects included in Group Wave 19: 2C-D.E. and BH (20' top cage). It is assumed that one basic tower of each type will be modeled as well as one extension for each tower type will be modeled/designed.

Burns & McDonnell has performed preliminary over-tension analyses for the circuits in this RFP. This preliminary analysis has only identified the sections of the affected circuits. A final detailed over-tension analysis will be completed as part of our engineering services and is included in our pricing, the results of which will be reported and presented to PG&E, in the format of PG&E's choosing, for further consideration. The results of our preliminary analyses are listed by circuit below.

Moraga-Lakewood 115kV

- Raise eight (8) SIERRA-STD towers and one (1) 2A tower at Structures 012/089, 011/084, 010/080, 009/071, 008/061,008/059, 008/057, 007/048, and 006/046.
- Replace two (2) lattice poles with steel poles at Structures 00/004B and 00/006B.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 011/083 to 009/070. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moraga-Oakland "J" 115kV

- Raise one (1) 2A tower and one (1) 2C-D.E. tower at Structures 006/044-M and 009/065-M.
- Replace steel pole at Structure 04/050-OJ.
- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moraga-San Leandro #1 115kV

- Raise two (2) AH towers and two (2) BH towers at Structures 001/013, 004/032, 007/054, and 008/058.
- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moraga-San Leandro #2 115kV

- Raise one (1) BH tower at Structure 005/042.
- Replace steel pole at Structure 010/071.
- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Moraga-San Leandro #3 115kV

- Raise one (1) 2BO tower at Structure 009/062.

- ***Based on preliminary analysis, there are no NERC affected sections with existing over-tension issues. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Group Wave 20

We have included the following project specific Scope of Work and Assumptions for the projects in Group Wave 20.

Group Wave #	Proj Title #	Circuit Name	PGE Job Order #	Circuit #	Mileage	# Spans	Discrepancies	Steel Locations	Tentative IFC Date	Shared Circuit Name
20	W20-1	Vaca-Vacaville-Cordelia 115kV	30932709	10347	22.0	157	35	11	9/1/2014	Vaca-Vacaville-Jameson-North Tower
	W20-2	Vaca-Vacaville-Jameson-North Tower 115kV	30932710	10348	36.1	251	68	36	9/1/2014	Vaca-Vacaville-Cordelia 115kV, Ignacio-Mare Island #2 115kV
			Wave 20 Totals		*58.1*	*408*	*103*	*47*		

The following PG&E tower types and top/waist cage extensions have been modeled for previous projects and will be used for the projects included in Group Wave 20: A, B, and 2B.

The following tower types and top cage extensions will need to be modeled to be used for the projects included in Group Wave 20: L and CH-D.E. One unknown tower type will also need to be modeled and will potentially require a new extension design. One basic tower of each type will be modeled as well as one extension for each tower type will be modeled/designed.

Burns & McDonnell has performed preliminary over-tension analyses for the circuits in this RFP. This preliminary analysis has only identified the sections of the affected circuits. A final detailed over-tension analysis will be completed as part of our engineering services and is included in our pricing, the results of which will be reported and presented to PG&E, in the format of PG&E's choosing, for further consideration. The results of our preliminary analyses are listed by circuit below.

Vaca-Vacaville-Cordelia 115kV

- Raise nine (9) A towers and two (2) B towers at Structures 005/041, 005/044, 011/080, 015/102, 015/105, 015/107, 016/112, 016/114, 017/116, 017/117, and 017/118.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 004/036 – 017/120. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Vaca-Vacaville-Jameson-North Tower 115kV

- Raise one (1) 2B tower, three (3) L towers, fourteen (14) A towers, three (3) B towers, one (1) BH-D.E. tower, seven (7) AH towers, one (1) CH-D.E. tower, and three (3) unknown tower at Structures 003/025, 003/027, 003/029, 004/037, 005/039, 006/046, 006/048, 006/050, 007/058, 008/060, 008/062, 012/086, 012/088, 013/094, 014/096, 014/098, 014/100, 017/119, B18/125*, B18/127*,

24/169*, A04/039, 017/125, 020/142*, 021/147*, 024/168*, 025/174*, 025/180*, 027/186*, 027/189*, GDI 203.

- Replace three (3) steel poles at Structures A05/046, 017/124, and GDI 204.
- ***Based on preliminary analysis, NERC affected sections with existing over-tension issues: 004/036 – 017/120. A complete analysis will be performed in compliance with "Overhead Transmission Line Design Criteria – 068177" during the scope of engineering services.***

Prepared by: ABB

PG&E	**OVERHEAD TRANSMISSION LINE DESIGN CRITERIA**	**068177**
Asset Type: Electric Transmission	**Function:** Construction and Maintenance	
Issued by: Randy L. Hopkins (RLHa) Randy L. Hopkins	**Date:** 06-28-13	
Rev. #10: This document replaces PG&E Document 068177, Rev. #09. For a description of the changes, see Page 16.		

Table of Contents

Purpose and Scope

Proper transmission line (T/L) design requirements are necessary for the safe, reliable, and economic construction and operation of high-voltage transmission lines. This document outlines the minimum criteria to be used in the design of all PG&E overhead transmission lines. The electrical and structural limitations described in the criteria may be increased depending on local conditions or specific project-related requirements. The use of the criteria is intended only for experienced employees with a working knowledge of transmission line design and construction practices.

Any deviations from this design criteria resulting in the lowering of the electrical clearances or mechanical safety factors below *General Order (G.O.) 95* are not allowed. Deviations resulting in less than criteria requirements but still meeting *G.O. 95* should be made only under unusual circumstances. If a deviation is made from the design criteria, the project engineer shall submit a letter describing the deviation and giving the reasons for the deviation or criteria change. If structural loading is involved, a civil engineer must approve and sign off on the letter. The supervisors of T/L engineering and T/L standards personnel must also approve and sign the letter. The signed letter shall be included in the job file for future reference.

References	**Location**	**Document No.**
Methods of Grounding Steel Transmission Poles and Towers	TIL	012566
Suspension-Type Insulators	OH: Transmission	015014

References (continued)	Location	Document
Vibration Damper Requirements for Various Types of Overhead Conductors	OH: Conductors	015073
Strength Requirements for Wood Poles	OH: Framing/EDM	015203
Method of Grounding Fences and Wire Trellises	OH: Transmission	020607
Installation of Grounds on Wood Pole Transmission and Distribution Lines	OH: Transformers	021904
Clearance Tables CPUC General Order 95	OH: Clearances	022158
Vertical Separation of Overhead Transmission, Distribution, and Telephone Circuits	OH: Clearances	022187
Insulation Districts for Overhead Lines and Stations	OH: General	026300
Ampacity of Overhead Line Conductors	OH: Conductors/EPM	030559
Transverse Loading Limitations Design Criteria for 44–115 kV Pole Lines	ELS	032550
Transverse Loading Design Criteria for 44–115 kV Pole Lines	ELS	032551
Single Vertical Limitations Design Criteria For 44–115 kV Pole Lines	FRO: Transmission	032552A
Structural Limitations Design Criteria For 44–70 kV Pole Lines	ELS	032553
Instructions Design Criteria for 44–70 kV Pole Lines	ELS	032583
Corrosion Area Overhead Lines	OH: General/EPM	032911
Application of Aluminum Conductors and Connections for Substation Use	TIL	037788
Triangular Construction 115 kV Wood Pole Lines	ELS	048873
Structural Limitations Design Criteria for 115 kV Wood Pole Lines	FRO: Transmission	048874A
Line-Tension Type Air Switch Installation 44–70 kV Pole Lines	ELS	048876
Tubular Steel Poles	ELS	051742
Post-Type Insulators 60–115 kV Transmission Lines	OH: Transmission	051762
Snow Loading Map	EDM	054330
Conductors for Overhead Lines	OH: Conductors	059626
Installation of Fiberoptic Communication Cable on Wood Pole Distribution Lines	FRO: Framing	062719A
Installation of Switch Grounds on Steel Structure 60-230 kV Transmission Lines	ELS	065383
Post-Type Apparatus Insulators	TIL	067906
Grounding Requirements For Outdoor Electrical Substations	TIL	067910
115 kV and 230 kV Line Switches Mounted on Transmission Structures	ELS	463236
Electrical Clearances for 60 kV, 70 kV, 115 kV, and 230 kV Overhead Transmission Lines	ELS	470591
UO Guideline G11030, "Overhead Transmission Line Naming and Line Numbering"	TIL	G11030
UO Guideline G11073, "Numbering and Marking Overhead Transmission Line Structures"	TIL	G11073
General Order (G.O) 95	TIL	*G.O. 95*
UO Standard S1072, "Requirements for Marking, Guarding, and Stepping of T&D Towers and Lattice Steel Poles"	TIL	S1072
TD-1006S, "Transmission Line Air Switches"	TIL	TD-1006S
WP1902, "Evaluating Uses of Company Transmission Line Easements by Others"	TIL	WP1902

Wood and Light Duty Steel Pole Transmission

The design criteria for wood pole line construction are described in Documents 048874A and 032583. The preferred design for all wood pole and LDS pole construction is 115 kV with the following exceptions:

1. Retain 60-70 kV switches and switch installations. Install spill gaps on 115 kV insulated structures ahead and back of 60-70 kV switches.
2. For reconductor projects, maintain 60-70 kV phase spacing if existing poles are correctly sized for the new conductor and pole replacements can be avoided.
3. On delta and vertical construction, do not mix 60-70 kV and 115 kV phase-to-phase separation.

Where 60-70 kV circuits are constructed at 115 kV, communicate the design information to system protection personnel and substation engineering personnel.

Structural Requirements

Light duty steel (LDS) is the preferred construction for "wood pole" type projects. For LDS poles, the preferred material type is corten (weathering) steel. Galvanized steel is preferred in coastal or other wet environments.

The following criteria shall be used to determine the structure material:

Light Duty Steel Poles

- If the pole is to support only a transmission circuit and there are no arc-flash hazards or no step-and-touch potential issues as described in the section on "Arc Distance Criteria" elsewhere in this document, use a light duty tubular steel pole.
- If the pole is to support a transmission switch (with or without distribution under-build), use a light duty tubular steel pole. If there are other factors that prohibit the use of steel switch pole, consult with transmission line engineering for appropriate pole selection.
- If the transmission structure supports a 4-wire system distribution under-build circuit, with a continuous common neutral between two substation terminals, use a light tubular steel pole.

Wood Poles

- If required safe arc distance cannot be achieved using mitigation methods as outlined in the section on "Arc Distance Criteria", use a wood or other non-metallic structure.
- If the transmission structure supports distribution under-build circuits other than the 4-wire systems described above, use a wood pole.
- If the pole line is oriented parallel and adjacent to (within 8-feet) a fence comprised mostly of metallic components, use wood poles when replacing poles adjacent to the fence line.
- During a wood pole replacement project, if a minimum number of wood poles are being replaced and access to the pole site is difficult, use wood poles.
- If the existing right-of-way description requires that only wood poles be installed, use wood poles.

The minimum pole class, due to transverse loading and depth setting, shall be determined using Document 032550. The minimum pole class, due to column loading, shall be determined using Document 015203. Additional structural limitation drawings are shown in Table 1 below.

Table 1 Structural Limitation Drawings for 44-115 kV Wood Poles

Title	Document Number
Transverse Loading Design Criteria for 44-115 kV Pole Lines	032551
Single Vertical Limitations Design Criteria for 44-115 kV Pole Lines	032552A
Structural Limitations Design Criteria for 44-70 kV Pole Lines	032553
Structural Limitations Design Criteria for 115 kV Wood Pole Lines	048874A

The grade of construction for transmission wood pole lines 44 kV to 115 kV shall be in accordance with the following table (*G.O. 95*, Rule 42, Table 3):

Wood and Light Duty Steel Pole Transmission (continued)

Table 2 Grade of Construction

Circuit at Upper Level	Condition	Grade of Construction Required
All Voltages	Crossing Major Railway	A
Over 5,000 V	Crossing, Joint With, or in Conflict With Communication Circuit	A
All Voltages	Crossing Minor Railway	B
Over 5,000 V	No Crossing Involved	B
Over 5,000 V	Distribution Under Build	B

Where two or more conditions affecting the grade of construction exist, the grade of construction used shall be the highest required under any of the conditions (*G.O. 95*, Rule 42.1). Although minimum wood pole safety factors may be reduced by 2/3 of their required value "due to deterioration or changes in construction arrangement or other conditions subsequent to installation" (*G.O. 95*, Rule 44.2), any additional attachments to a pole will require that the pole be brought up to the full "at installation" safety factor requirements for the applicable grade of construction.

An extreme wind loading criteria shall be applied on new, relocated, and/or replaced transmission structures. This criteria is not applied whenever a pole is "touched," such as when moving conductors or installing communication antennas on an existing structure. Wood poles that are installed or replaced for any reason, and are located in areas subject to winds greater than 70 mph, shall have the size increased by one pole class larger than the pole size required by Document 032550.

Insulation Criteria

For wood pole construction, non-ceramic insulators are preferred for post and dead-end applications. Determine the number and type of insulators required for suspension and dead-end-type insulator strings, or the type of post insulators required for post construction, by the insulation district or contamination area. The insulation districts are shown in Document 026300. The number of units for contaminated areas is shown on Document 015014. Post-type construction is shown in Document 051762.

60-70 kV Transmission Line Conversion to 115 kV Insulation

For future construction, existing 60-70 kV lines will be built using 115 kV type construction. Exceptions can be made for maintenance and minor reconstruction. When 60-70 kV circuits are constructed with 115 kV insulators and/or 115 kV phase-to-phase separation, System Protection and Substation Project Engineering must be informed so that the impacts can be assessed.

For 60-70 kV lines converted to 115 kV insulation, use the following criteria:

- 115 kV phase-to-phase and circuit-to-circuit separation.
- 115 kV material – insulators and hardware
- For reconductoring projects, maintain 60-70 kV framing if the poles are in good condition and are correctly sized for the new conductor – do not change out poles. (Note: The use of safety factor reduction for reconstruction is not approved for transmission lines.)
- To avoid replacing a good pole, use 60-70 kV phase-to-phase, circuit-to-circuit, and circuit-to-underbuild separation.
- When 115 kV insulation is used on a 60-70 kV line, gapped arresters must be installed between the line and the substation breaker.
- When 115 kV insulation is used with 60-70 kV insulated line switches, spill gaps must be installed on the adjacent structures on either side of the switch. For installation of line spill gaps, see UO Bulletin 2009-24 R1.
- Install grounds on all structures with spill gaps or gapped arresters.
- Install new 60-70 kV switches when existing structures in the same section of circuit are framed and constructed for 60-70 kV.
- Install new 115 kV switches when a section of circuit is being framed and constructed at 115 kV.
- Consider aesthetics - On delta or vertical post construction, do not mix 60-70 kV and 115 kV phase-to-phase separation.

- If existing poles are not adequate for a reconstruction project, then reconstruct using 115 kV insulation, clearances, and separations.

Steel and Other Non-Wood Pole Transmission

Structural Requirements

Safety factors shall be based on the maximum conductor tension and under the maximum design wind load.

For the **intact** conditions, all steel transmission line facilities shall be designed for *G.O. 95*, Grade "A" construction safety factors. (See *G.O. 95*, Table 4, for a list of safety factors for each type of material.)

In addition to the above criteria, all steel structures shall be designed for **broken wire** criteria as described in Table 3. The conductors selected to calculate the broken wire longitudinal loads shall be selected so as to produce the maximum stress in the support structure. If the structure has an overhead ground wire, then the broken wire condition may include a broken ground wire in place of a broken conductor, if that produces the maximum stress. Grade A construction for steel structures is defined in CPUC *G.O. 95*, Rule 47.5. (Wood poles are normally not designed for broken wire capability, unless required by the CPUC's *G.O. 95* Rule 47.5.)

Table 3 Minimum Safety Factors

Structure Type	Number of Broken Wires	Safety Factor
Tangent Suspension	1/3 Wires Broken	1.0
Non-Terminal Dead End (new structure)	1/3 Wires Broken	1.5
Non-Terminal Dead End (rebuild)	1/3 Wires Broken	1.0
Terminal Dead End	All Wires Broken (see Note 1)	1.5
Substation Tap/Loop Dead End	All Wires Broken (see Note 2)	1.0

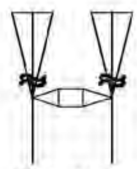

Figure 1
Terminal Dead End

Note:

1. A **terminal dead end** is defined as the first (or last) structure on a line at a substation or transition station. This structure should be capable of supporting the unbalanced load from the termination of all conductors on the high-tension or line side with a safety factor of 1.5 (see Figure 1).

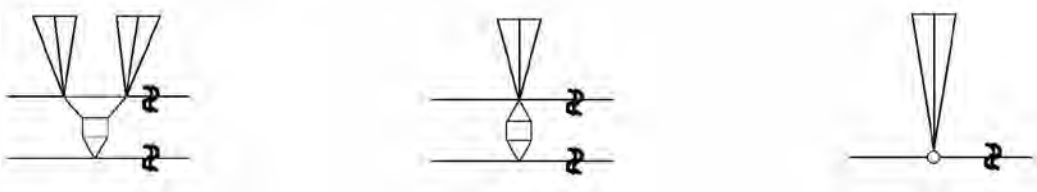

Figure 2
Substation Tap/Loop Dead End

Note:

2. A **substation tap/loop dead end** is defined as the structure in a transmission line that is used to tap-off or loop into a substation. This structure should be capable of supporting the termination of all conductors on the high-tension "main-line" side with a safety factor of 1.0 (see Figure 2).

Steel and Other Non-Wood Pole Transmission (continued)

Anti-Cascade Loading Criteria

Towers on some existing tower lines may not be able to meet the broken wire criteria as specified above. Except for towers over Grade A crossings, the broken wire requirements for existing towers may be waived by the transmission line engineering supervisor, however, the line shall meet the cascade mitigation criteria given below. Towers over Grade A crossings shall meet the broken wire conditions as required by *G.O. 95*.

Per Rule 61.3-B of *G.O. 95*, a transmission line, as a whole, shall be designed so that a failure of an individual support structure shall not cause successive failures of more than 10 additional support structures. This can be accomplished by:

1. Having stop towers at intervals less than 10 towers.
2. Designing all towers for a minimum residual static load (RSL) at 1/3 of the conductor attachment points. For a single-circuit tower, apply the RSL at the attachment of any one conductor or one shield wire. For a double-circuit tower, apply the RSL at the attachments of any two conductors, or two shield wires, or one conductor and one shield wire.
3. Using load limiters to reduce unbalanced loads.

The use of Methods 2 and 3 above need pre-approval of the transmission line engineering supervisor.

The RSL for the conductor is the broken wire load based on everyday tension (EDT) at 60°F, no wind, no ice, final sag. The RSL for the shield wire is the full EDT load.

Maximum Loading Condition Criteria

The maximum loading condition is used to determine the maximum conductor tension, the minimum safety factors, and the broken wire loads.

Table 4 Maximum Loading Conditions

Loading Condition	Elevation (feet)	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
Light	0-1,500	25	0	8	Initial
Intermediate	1,501-3,000	0	1/4	6	Initial
Heavy	Over 3,000	0	1/2	6	Initial
Extra Heavy	As Required	0	3/4 or More	6	Initial

Initial is defined as the conductor tension at 1 hour for all loading areas and conductor types.

Snow loading areas are shown in Document 054330. These maps are based on local experience and should be used regardless of structure elevation. However, structures located at elevations over 3,000 feet shall be designed for heavy loading or greater. Experience with very wet snows may indicate that a particular line should be designed for greater than heavy loading.

Differential Ice Loading Requirements

The minimum distance between phase conductors of the same circuit and between phase conductors and overhead ground wire on the same structure under differential ice loading conditions is given in Table 5 on Page 7.

Steel and Other Non-Wood Pole Transmission (continued)

Table 5 Minimum Separation in Any Direction Between Phase Conductors and Between Phase Conductors and Overhead Ground Wires

Voltage (kV)	Minimum Separation [1]	
	Phase-to-Phase (feet)	Phase-to-OHGW (feet)
60 and 70	1.8	1
115	3	1.8
230	6	3.5
500	NA [2]	8

[1] If one conductor is located directly above another, or if there is less than 1 foot of horizontal offset, maintain 2 feet of clearance, in addition to that specified in Table 5.

[2] In intermediate and heavy ice or snow loading areas, 500 kV construction shall be horizontal.

Conditions under which clearances apply:

- Upper Conductor – 32°F, final sag, with a radial thickness of ice equal to the maximum thickness of ice that can be reasonably expected for the geographical area.
- Lower Conductor – 32°F, final sag, no ice.

Extreme Wind Loading Criteria

The extreme wind loading criteria shall be applied on new construction, relocations, reconductor, and fiberoptic projects. This criteria is not applied whenever the tower is "touched", such as when installing extensions to correct existing ground clearance infractions, modifications, or installation of communication antennas.

All new, relocated, replaced, and existing structures that are used for reconductoring and fiberoptic wire installations shall be designed for wind speed shown on PG&E's extreme wind map. Wind pressure shall be calculated according to the National Electric Safety Code (NESC) 2002 based on 3-second gust wind speed and applied to the wires and structure with a safety factor of 1.0. A conversion factor of 1.2 shall be used to convert the 1-minute average wind speed value from PG&E's extreme wind map to a 3-second gust value.

Maximum Conductor Tension Criteria

The conductor tensions listed in Table 6 are for horizontal, bottom of the catenary tensions. Under no condition, should the resultant tension exceed 50% (*G.O. 95*, Rule 44, Safety Factors).

Table 6 Maximum Conductor Tension Criteria

Conductor	Initial		Final
Type	Maximum Loaded	60°F	40°F
AAC	45%	35%	25% [1]
ACSR	45%	35%	25% [1]
ACSS	45%	35%	25% [1]
Copper	45%	35%	25% [1]

[1] For span lengths between 1,800–2,500 feet, the maximum conductor tension shall not be greater than 22.5%. For spans greater than 2,500 feet, the maximum conductor tension shall not be greater than 20%.

Calculate the final sag to produce the maximum sag at one of the following two conditions:

- Final conductor sag after creep at 40°F, bare conductor.
- Final conductor sag after creep, with the loaded condition as described in Table 4 on Page 6.

Insulation Criteria

Determine the number and type of insulators required for suspension and dead-end type insulator strings by the insulation district or contamination area. The insulation districts are shown in Document 026300. The number of units for contaminated areas is shown on Document 015014. Post-type construction is shown in Document 051762.

For suspension and dead-end insulator strings, porcelain or glass insulators are the preferred construction material. In areas of high contamination where washing is required on porcelain or glass insulators, or in areas subject to gunshots, non-ceramic insulators may be substituted. For post insulators, non-ceramic insulators are preferred, though porcelain insulators may be substituted.

Requirements for hardware in corrosive areas are shown in Document 032911.

60-70 kV Transmission Line Conversion to 115 kV Insulation

For future construction, existing 60-70 kV lines will be built using 115 kV type construction. Exceptions can be made for maintenance and minor reconstruction. When 60-70 kV circuits are constructed with 115 kV insulators and/or 115 kV phase-to-phase separation, system protection and substation project engineering must be informed so that the impacts can be assessed.

For 60-70 kV lines converted to 115 kV insulation, use the following criteria:

- 115 kV phase-to-phase and circuit-to-circuit separation.
- 115 kV material – insulators and hardware.
- For reconductoring projects, maintain 60-70 kV framing if the poles are in good condition and are correctly sized for the new conductor — do not change out poles. (Note: The use of safety factor reduction for reconstruction is not approved for transmission lines.)
- To avoid replacing a good pole, use 60-70 kV phase-to-phase, circuit-to-circuit, and circuit-to-underbuild separation.
- When 115 kV insulation is used on a 60-70 kV line, gapped arresters must be installed between the line and the substation breaker.
- When 115 kV insulation is used with 60-70 kV insulated line switches, spill gaps must be installed on the adjacent structures on either side of the switch. For installation of line spill gaps, see UO Bulletin 2009-24 R1.
- Install grounds on all structures with spill gaps or gapped arresters.
- Install new 60-70 kV switches when existing structures in the same section of circuit are framed and constructed for 60-70 kV.
- Install new 115 kV switches when a section of circuit is being framed and constructed at 115 kV.
- Consider aesthetics - On delta or vertical post construction, do not mix 60-70 kV and 115 kV phase-to-phase separation.
- If existing poles are not adequate for a reconstruction project, then reconstruct using 115 kV insulation, clearances, and separations.

Electrical Clearances

General Notes

1. Electrical clearances for all transmission lines must meet or exceed the requirements of *G.O. 95*. Use tables in this section for electrical clearance requirements.
2. Measure all clearances from surface to surface. Measure all spacing from center to center.
3. For clearance measurements, consider live metallic hardware that is electrically connected to line conductors as a part of the line conductors.
4. Increase all minimum clearances 3% for each 1,000 feet in excess of 3,300 feet above mean sea level.
5. If specific clearances are not identified in this document, use Document 022158 for clearance requirements.

Electrical Clearances (continued)

6. Where additional circuits are installed under a 115 kV transmission circuit, the required conductor separation at the pole between the transmission conductor and distribution conductor is shown in Document 048873. For 60 and 70 kV transmission wood pole lines, the required conductor separation at the pole between transmission conductor and distribution conductor is listed in Document 022187. The midspan conductor separation shall meet or exceed the electrical clearance requirements in Document 022158 (for 115 kV lines, use *G.O. 95*, Table 2, Cases 8 – 13).

Criteria for Checking Minimum Electrical Clearances Above Ground, Roads, and Railroads

Table 7 Loading Conditions: Normal Clearances to Ground

Loading Condition	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
Light	60	0	0	Final
Intermediate	60 and 32	0 1/4	0 0	Final Final
Heavy	60 and 32	0 1/2	0 0	Final Final

Table 8 Loading Conditions: Emergency Clearances to Ground

Conductor Type	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
AAC	185 (85°C)	0	0	Final
ACSR	194 (90°C)	0	0	Final
ACSS	392 (200°C)	0	0	Final
Copper	185 (85°C)	0	0	Final

Table 9 Standard Design Clearances to Ground [1]

Voltage	Situation	Normal Clearance (feet)	Emergency Clearance (feet)
500 kV	Cultivated Agriculture	40	33
500 kV	Other New Lines	37	33
500 kV	County Roads and Highway "X"	56	33
230 kV	New Line	32	29
230 kV	Rebuild Line	31	28
115 kV	New Line	32	29
115 kV	Rebuild Line	31	28
60–70 kV	New Line	32	29
60–70 kV	Rebuild Line	31	28
12 kV	All	25	22.5
Telephone	All	18	–

[1] The criteria for minimum clearance over railroad tracks and bodies of water are outlined in *G.O. 95*, Rule 37.

Electrical Clearances (continued)

Criteria for Checking Minimum Electrical Clearances From Other Wires, Structures, and Supports

Table 10 Loading Conditions: Electrical Clearance (all situations)

Condition	Circuit	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
No Wind	Upper	60	0	0	Final
With Wind	Lower	60	0	8	Final

Table 11 Loading Conditions: Clearance to Other Structure (minimum required electrical clearances must be maintained for each of the conductor conditions and the conditions in Table 10)

Loading Condition	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
Light	25 25 130	0 0 0	8 0 2	Initial Initial Final
Intermediate	0 25 25 130	1/4 0 0 0	6 8 0 2	Initial Initial Initial Final
Heavy	0 25 25 130	1/2 0 0 0	6 8 0 2	Initial Initial Initial Final

Table 12 Loading Conditions: Clearance at Crossings and Underbuild (maintain the minimum required electrical clearances for each of the conditions and the conditions in Table 10)

Loading Condition	Case	Circuit	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
Light	1	Upper Lower	MOT [1, 2, 3] 60	0 0	0 0	Final Final
Intermediate	1	Upper Lower	32 32	1/4 0	0 0	Final Final
	2	Upper Lower	MOT [1, 2, 3] 60	0 0	0 0	Final Final
Heavy	1	Upper Lower	32 32	1/2 0	0 0	Final Final
	2	Upper Lower	MOT [1, 2, 3] 60	0 0	0 0	Final Final

1 Clearances should be based on "Upper" circuit at its maximum operating temperature (MOT).

2 For ACSS conductor, use 392°F as the upper circuit operating temperature.

3 For MOT of conductors other than ACSS, see Document 030559, "Ampacity of Overhead Line Conductors".

Minimum electrical clearances from other wires, structures, and supports are shown in Document 470591, "Electrical Clearances for 60 kV, 70 kV, 115 kV, and 230 kV Overhead Transmission Lines." The clearances in this document have been established by an air gap analysis of PG&E's voltage levels, maximum expected switching surges, and air quality. These values are very similar to the minimums set forth in the National Electric Safety Code (NESC). In all cases, these values meet or exceed the minimum values set forth in the CPUC's *G.O. 95*.

In general, all new non-wood transmission lines should be designed to allow for live-line maintenance work. Live-line techniques are PG&E's preferred maintenance method for transmission lines. Electrical clearances for barehand work are described in the Electric Transmission Live-Line Barehand Work Procedures Manual. In designing for barehand work, it is important to work with transmission line specialist(s) on the clearances because the requirements may vary depending on the structure type, conductor configuration, and access.

For antenna installations on towers, minimum clearances are per Cal/OSHA, Section 2946, Table 1. The antenna and its support are considered to be part of the tower. CPUC *G.O. 95* electrical clearances are not the limiting factor.

Electrical Clearances (continued)

In addition, all new, reconstructed, and/or re-permitted transmission structures that are located in raptor **high-risk areas** must be designed and constructed to be raptor-safe in accordance with the specifications found in the Edison Electric Institute's "Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996."

1. For non-wood construction, with post insulators, use 115 kV insulators for 60-70 kV lines. For a raptor sensitive location, provide a minimum phase to ground clearance of 51".
2. For transmission line transposition structures, reasonable attempts may be made to achieve the maximum clearance with reasonable efforts, such as using outrigger crossarms on a lattice tower, a two-structure configuration (rolling transposition) or using post insulator type construction for vertical drops.
3. In some cases, the use of suspension insulator jumpers may result in reduced raptor-safety electrical clearances. In such events, it may be possible to substitute post insulators in place of suspension insulator in vertical position. This may require modifications on a structure to accommodate the post insulators.

In case of an installation of a 60-70 or 115 kV line switches, it is not practical to achieve recommended clearance, so these switches are excepted from these clearance requirements.

Right of Way Width

Determine the right of way width from the centerline for a single span by summing the following distances:

- Structure width from the centerline.
- Conductor and insulator swing under R/W loading conditions.
- 6-foot buffer.

When determining the right of way width for an entire line, the preferred practice is to use one width for the line and to base that width on a relatively long span within the line (not the longest span). Additional width shall then be added, as appropriate, for those spans that exceed this base span. For long canyon spans, if the minimum conductor height above ground exceeds 50 feet, do not expand the right of way width to accommodate the extra conductor sway.

For parallel transmission lines, determine the centerline separation by calculating the maximum clearance from the following criteria:

1. OSHA Clearance (required for the inside circuit of multiple-circuit corridors)
   - Structure width from the centerline.
   - Twice the OSHA Section 294, Table 2 clearances.
   - Crane width (4 feet).
   - Crane movement (5 feet).
2. Circuit-to-Circuit Sway Clearance
   - Conductor and insulator swing under non-stagger loading conditions.
   - Minimum circuit-to-circuit electrical clearances.
3. Stagger Limitations Clearance (where structures on adjacent lines are staggered)
   - Insulator and conductor swing under R/W loading condition.
   - Minimum circuit-to-steel electrical clearances.

Table 13 Right of Way Width Loading Conditions

Situation	Temperature (°F)	Ice (inches)	Wind (lbs./sq. ft.)	Time
Right of Way Width	60	0	8	Final

Table 14 Stagger Limitations Loading Conditions

Description	Loading Condition
No Stagger, Phase-to-Structure (check both conditions)	60°F, 8#, Final vs. 60°F, 6#, Final 60°F, 2#, Final vs. 60°F, 0#, Final
Unlimited Stagger, Circuit-to-Circuit	60°F, 8#, Final

Joint Use Corridors

Transmission line right of ways should normally be clear of encumbrances such as above ground structures or underground pipelines. The unencumbered right of way is required to allow for proper maintenance of the transmission facility and to minimize any electric hazards. PG&E right of way widths are generally adequate to protect structures located outside the right of way boundary. Refer to Utility Work Procedure WP1902 on the use of PG&E lands and easements by others.

Induction Distance Criteria

- If the underground metal pipeline is outside the right of way, no action is required by PG&E.
- If the pipeline is within the right of way and parallel to the transmission line for more than 1 mile, a detailed induction analysis must be performed to assess the specific condition and, if required, to determine the proper mitigation.
- No action is required if the pipeline is not parallel to the transmission line.
- Special analysis is required for transmission lines located adjacent to railroads.

Arc Distance Criteria (parallel or perpendicular metallic pipeline crossings, metal fences, etc.)

In no case shall the concrete footing of a steel structure or the direct embedded portion of a steel or concrete structure be located closer than the arc distance “D” to an underground metal object. A typical underground metal object is defined as a pipeline or metallic foundations (metal fences, power panels with ground rods, etc.)

If the underground metal object is more than 25 feet from the transmission steel structure, no additional study is required.

If the 25-foot distance cannot be maintained, the following formula may be used to estimate the arc distance “D” from the footing of a transmission structure to an underground metal object.

$D = 0.26 (\rho J)^{1/2}$ where:

- “D” is the distance from the footing of a transmission structure to an underground metal object.
- “ρ” is the average soil resistivity in ohm-meters
  - If the soil resistivity is known, use actual values
  - if unknown, use 100 ohm-meters for non-mountainous areas and 1000 ohm-meters for mountainous areas.
- “J” is the fault current in kA

If the arc distance “D” cannot be achieved using the above formula, use detailed analysis techniques to provide specific mitigation.

Above Ground Touch Hazards

No above ground metal objects (chain link fences, metal streetlights, metal sheds, etc.) should be within 8 feet of a steel or concrete structure.

Parallel Ties Between Circuits

For protection reasons, when paralleling two circuits on the same structure, maintain a minimum of six parallel ties between circuits between any two substations, and one tie every 5 miles for 25-mile or longer lines. Use a maximum of 11 equidistant ties for lines 50 miles or longer. For short lines, the requirement may be reduced after being examined on a case-by-case basis by system protection personnel.

Mitigation of Inductive Interference With Communication Lines (G.O. 52)

Parallels

Every reasonable effort shall be made to avoid creating parallels with communication facilities. If the construction or reconstruction of a transmission line may create a parallel with a communication circuit, permission must be received from the communication companies to allow the parallel construction (G.O. 52, Rule IIb).